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Serial No. 10/581,027
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AMENDMENTS TO THE SPECIFICATION:

Page 1, after the title, insert the following heading and sub-heading:

BACKGROUND

1. Technical Field

Page 1, following paragraph [0001], insert the following sub-heading and text:

2. Related Art

There is extensive prior art in the field of image processing. One example is Brett, U.S. Patent No. 5,850,471, directed to high-definition digital video processing, wherein a given pixel value is compared to its neighbors and, under certain conditions, is replaced by an average value. In effect, this is a smoothing filter that may be used to remove noise. Other prior art is discussed below.

Page 1, insert the following heading immediately preceding paragraph [0002]:

BRIEF SUMMARY

Page 1, paragraph [0002]:

[0002] According to the present invention exemplary embodiments, there is provided a method of processing a digitally coded image in which picture elements[''] are each represented by a colour color value, comprising, for each of a plurality of said picture elements:

Page 1, paragraphs [0004]-[0006]:

[0004] (b) when at least one comparison results in a match, computing a replacement colour color value for the picture element under consideration, the

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replacement ~~colour~~ color value being a function of the ~~colour~~ color value for the base picture element of the or each second group for which a match was obtained.

[0005] Preferably, the method includes identifying picture elements which meet a criterion of distinctiveness, and computing a replacement ~~colour~~ color value only for picture elements not meeting the distinctiveness criterion.

[0006] Other, preferred, aspects of the ~~invention~~ exemplary embodiments are defined in the appended claims.

Page 1, insert the following heading between paragraphs [0006] and [0007]:
BRIEF DESCRIPTION OF THE DRAWINGS

Page 1, insert the following heading between paragraphs [0012] and [0013]:
DETAILED DESCRIPTION OF EXEMPLARY EMBODIMENTS

Page 2, paragraphs [0014]-[0015]:

[0014] In the memory 6 are stored an operating system 601, a program 602 for performing the image analysis, and storage areas 603, 604 for storing an image to be processed and a processed image, respectively. Each image is stored as a two-dimensional array of values, each value representing the brightness and/or ~~colour~~ color of a picture element within the array.

[0015] In a first embodiment of the invention, the program 602 is arranged to operate as shown in the flowchart of FIG. 2. The image to be processed is stored as an array [C] of pixels where the position of a pixel is expressed in Cartesian co-ordinates, e.g. (x_1, x_2) or as a vector (in bold type), e.g. $\mathbf{x}=(x_1, x_2)$. The ~~colour~~ color of a pixel at \mathbf{x}

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is stored as a vector $\mathbf{C}(\mathbf{x})$ consisting of three components. In these examples r, g, b components are used, but other colour color spaces could be employed. In a monochrome system, \mathbf{C} would have only one (luminance) component. The results of this process are to be stored in a similar array \mathbf{C}_{OUT} .

Page 2, paragraphs [0017]-[0022]:

[0017] In Step 104, a comparison count I is set to zero, a match count M is set to 1, and a colour color vector \mathbf{V} is set to the colour color at \mathbf{x} . \mathbf{V} has three components which take values according to the colour color space employed, e.g. (r, g, b).

[0018] Step 106: n (typically 3) random pixels at $\mathbf{x}'_i=(x'_{i1}x'_{i2})$ $i=1, \dots, n$ are selected in the neighbourhood neighborhood of \mathbf{x} where

[0019] $|x'_j - x_j| < r_j$ for all $j=1, 2$ and r_j defines the size of a rectangular neighbourhood neighborhood (or square neighbourhood neighborhood with $r_1=r_2=r$). A typical value for r_j would be 2 for a 640×416 image.

[0020] Step 108: A pixel at $\mathbf{y}=(y_1, y_2)$ is then randomly selected elsewhere in the image and (Step 110) the comparison count I incremented. This pixel is selected to be $>r_j$ from the image boundary to avoid edge effects. If desired, the choice of \mathbf{y} could be limited to lie within a certain maximum distance from \mathbf{x} . If, at Step 112, the value of I does not exceed the value of a threshold L (typical values are 10-100), a test for a match between the neighbourhoods neighborhoods of \mathbf{x} and \mathbf{y} is carried out.

[0021] Step 114: Let the colour color of the pixel at \mathbf{x} be $\mathbf{C}(\mathbf{x})=(C_1(\mathbf{x}), C_2(\mathbf{x}), C_3(\mathbf{x}))=(r_x, g_x, b_x)$

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[0022] Then the ~~neighbourhoods~~ neighborhoods match if each of the pixels x , x' , (that is, the pixel under consideration and its n ~~neighbouring~~ neighboring pixels) matches the corresponding pixel at y , y' , where the positions of y'_i relative to y are the same as those of x'_i , relative to x . That is to say:

$$x - x' = y - y' \text{ for all } i=1, \dots, n.$$

Page 3, paragraphs [0025]-[0030]:

[0025] where d_j is a threshold that determines whether ~~colour~~ color component j is sufficiently different to constitute a pixel mismatch. In the tests described below, the ~~colour~~ color components were represented on a scale of 0 to 255 and a single value of $d_j=80$ was used. In general, d_j may be dependent upon x . For example, it may be preferred to model attention so that less emphasis is given to darker regions by increasing d_j in these areas.

[0026] If a match is found, then at Step 116 the counter M is incremented and the values of the ~~colour~~ color components at y are added to V .

$$V = V + C(y)$$

[0027] Following a match, the process returns to Step 106 of selecting a fresh ~~neighbourhood~~ neighborhood around x containing n random pixels, whereas if no match is found, it returns to Step 108 to select a new y without changing the pixel ~~neighborhood~~ neighbourhood.

[0028] If at Step 112, the value of I exceeds the threshold L , the ~~colour~~ color of the pixel at $x=(x_1, x_2)$ in the transformed image is given (Step 118) the average value of the ~~colours~~ colors of the M pixels found to have matching ~~neighbourhoods~~ neighborhoods, i.e.

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$$C_{\text{OUT}}(x) = V/M.$$

[0029] This process is repeated from Step 100 until all pixels in the image have been dealt with. The resulting transformed image possesses a much reduced spread of ~~colours~~ colors, but also contains small levels of noise arising from the random nature of the algorithm. This noise can be simply removed (Step 120) by applying a standard smoothing algorithm. In this embodiment, a pixel is assigned the average ~~colour~~ color of the pixels in the surrounding 3×3 window.

[0030] The algorithm shown in FIG. 2 processes all pixels x , and all will have their ~~colours~~ colors altered except in the case of pixels whose ~~neighbourhoods~~ neighborhoods are so dissimilar to the rest of the image that no matches are found. In that the process necessarily involves a loss of information, we prefer to identify important parts of the image and exclude these. Thus, the embodiment of FIG. 3 excludes regions of interest from the filtering process. In FIG. 3, those steps which are identical to those of FIG. 2 are given the same reference numerals.

Page 4, paragraph [0037]:

[0037] The degree of filtering that is applied to the image may be controlled by selecting the value of the thresholds d_j . Alternatively, or in addition, the filtering process can if desired be repeated: as shown at Step 170 in all three versions. The transformed image may be reloaded ~~whilst~~ while (in the case of FIG. 4) retaining the original attention scores $\text{Scores}(x_1, x_2)$ and the whole process repeated to obtain successive transformations and greater suppression of background information.

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Page 5, paragraph [0040]:

[0040] The results of applying the algorithm of FIG. 4 to a football source are shown in FIGS. 5a-c, which [[shows]] show, from left to right, FIG. 5a the original image (GIF format), FIG. 5b the image after JPEG coding, and FIG. 5c the image after filtering followed by JPEG CODING. Histograms of the distribution of hue values in the range 1-100 are also shown. It is found that the filtering reduces the compressed image file size from 13719 bytes to 10853 bytes.

Pages 5-6, paragraphs [0042]-[0046]:

[0042] FIGS. 6a-d illustrate illustrates how background information may be substantially removed whilst while preserving important features of the image such as the boat and the mountain outline. The original JPEG encoding (FIG. 6a) occupies 13361 bytes which is reduced to 10158 bytes after processing once and JPEG encoding the transformed version (FIG. 6b). The output image is reprocessed using the same VA scores and obtains a file size of 8881 bytes (FIG. 6c). A further iteration obtains a size of 8317 bytes (FIG. 6d).

[0043] This method may be applied with advantage to images containing artefacts artifacts (such as JPEG blocking effects). The re-assignment of colours colors to background regions tends to remove artefacts artifacts which normally possess some similarity to their surroundings ([[See]] see FIGS. 7a-b, where the original image is shown on the left[[:]]; on the right in FIG. 7b is shown the image obtained following processing with this method and subsequent re-coding using JPEG). However, artefacts artifacts which are very obtrusive and interfere with the main subject material will not be removed.

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[0044] A further application of the method is the enhancement of figure-ground or the removal of background distractions for improved recognizability recognisability. This application is illustrated in FIGS. 8a-b in which the background is almost completely replaced with a constant colour color and the image of the dog is much more prominent. The method could therefore be applied to the processing of images displayed in a digital viewfinder in a camera where the enhancement of subject material will assist photographers to compose their pictures.

[0045] Essential visual information is retained in the transformed images whilst while reducing the variability of colours colors in unimportant areas. The transformed images thereby become much easier to segment using conventional algorithms because there are fewer colour color boundaries to negotiate and shape outlines are more distinct. This means that this method will enhance the performance of many conventional algorithms that seek to partition images into separate and meaningful homogeneous regions for whatever purpose.

[0046] In the embodiments we have described, the replacement colour color value used is the average of the original value and those of all the pixels which it was found to match (although in fact it is not essential that the original value be included). Although [[it]] in practice this does not necessarily result in a reduction in the number of different colour color values in the image, nevertheless it results in a reduction in the colour color variability and hence – as has been demonstrated – increases the scope for compression and/or reduces the perception of artefacts artifacts in the image. Other replacement strategies may be adopted instead. For example, having obtained the average, the replacement could be chosen to be that one of a more limited (i.e. more coarsely quantized quantised) range of colours colors to which the average is closest.

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Or the match results could be used to identify groups of pixels which could then all be assigned the same colour color value.

Page 6, paragraph [0048]:

[0048] The second and third embodiments of the invention offer an approach to colour color compression that makes use of a visual attention algorithm to determine visually important areas in the image which are not to be transformed. This approach therefore possesses the significant advantage that the process of assigning region identities does not have to address the difficult problem of defining edges which normally hold the highest density of meaningful information. Non-attentive regions are transformed according to parameters derived from the same VA algorithm which indicates those regions sharing properties with many other parts of the image. The visual attention algorithm does not rely upon the pre-selection of features and hence has application to a greater range of images than standard feature based methods which tend to be tailored to work on categories of images most suited to the selected feature measurements. Pixels in the regions subject to transformation are assigned an average colour color and increased compression obtained through JPEG encoding or any other compression standard. Compression is applied to the least attentive regions of the image and, therefore, is unlikely to affect the perceptual quality of the overall image. The algorithm may be iteratively applied to the transformed images to obtain further compression at the expense of more background detail.

Page 7, top of page, delete "Claims" and insert the following heading:

WHAT IS CLAIMED IS: